Strategic Management of Egyptian-African Geothermal Power Plant Project 60-MW Associated with Sustainable Development in Kenya

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Strategic Management of Egyptian-African Geothermal Power Plant Project 60-MW Associated with Sustainable Development in Kenya

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Abstract. This paper presents the role of Egyptian government for satisfying sustainable development in African countries. However, Egypt has no geothermal power plant although there are many locations in eastern region of Egypt have sufficient quantity of geothermal energy resources. When the highest temperature of geothermal energy resources in Egypt is 51 °C, then it needs auxiliary heating system to produce electricity. So, Egyptian government uses geothermal energy resources as direct use in central heating system for agricultural applications or in physical therapy for encourage tourism sector in Egypt. Development of the African natural resources is considered the most important strategy of Egyptian Government and sharing African countries to obtain sustainability. Kenya is considered the unique country in Africa which utilizes geothermal energy resources for producing electricity. Geothermal Development Company GDC, Nairobi, Kenya produces 985 MW of electricity depending on geothermal energy resources in Kenya and this make Kenya in rank of sixth greatest country in the world utilizes geothermal energy resources for producing electricity after United States, Indonesia, Philippines, Turkey and New Zealand, respectively.

Keywords: geothermal energy resources, geothermal power plants, environmental and safety issues, greenhouse emissions, economic issues, Levelized Cost of Electricity LCOE.

1. Introduction

Environmental issues researchers must find more solutions for environmental problems that have direct passive impact on nature because of dependence on fossil fuel like coal, oil and natural gas for fuelling of power generation plants. Increasing of population in the World leads to increasing of energy demand. So, energy generation depends on fossil fuel can't satisfy the energy requirements. Then, energy generation researchers must have alternative energy generation techniques instead of fossil fuel. Most of African countries have planned to enhance sustainability like Egypt when signed on 19th November 2015 with Russian Rosatom Corporation to establish the first nuclear power plant in El-Dhabaa city, north of Egypt [1].

Geothermal energy technique is considered the best solution of renewable energy resources that support sustainability in Possible alternatives include low, lower-middle, upper-middle, and high-income countries as applicable, like African counties. Geothermal energy resources in Africa are

centralized in East Countries of Africa like Egypt, Sudan, South Sudan, Eretria, Djibouti, Somalia, Kenya, Ethiopia, Democratic Republic of Congo, Tanzania, Uganda, Rwanda, Burundi, Malawi, Zambia, Zimbabwe and Mozambique. Although geothermal energy is clean energy generation technique, but it is also economic energy generation type. United State of America has the greatest electricity generation in the World where produces 3900 MW electricity depends on geothermal energy resources. Also, Kenya is the unique African country utilizes geothermal energy resources for producing electricity, where the total geothermal power plants in Kenya produces 985 MW [2].

The Global energy transformation from fossil fuel technique to geothermal energy technique leads to reduce carbon dioxide emissions and prevent greenhouse gases. Ice Land is the best example, where it exploits its geothermal energy resources for producing 35% of electricity generated in Ice Land [2]. Italy is a member of the great industrial countries and the first country in the World utilizes geothermal energy resources for producing electricity in 1904. Methane is the major of greenhouse emissions due to coal-fired power generation plants. But transformation to gas-fired power generation plant is not optimum solution for reducing the rate of greenhouse emissions into the atmosphere [3]. So, renewable energy is the optimum solution for elimination of greenhouse emissions as well as it is consider economic power generation type and satisfies the sustainable development in the World. Geothermal energy is the best type of renewable energy for producing reliable power because it doesn't depend directly on the environmental circumstances like photovoltaic or wind power generation plants. Figure (1) shows the 10 top countries of the world which utilizes geothermal energy resources for producing electricity [2 and 3].

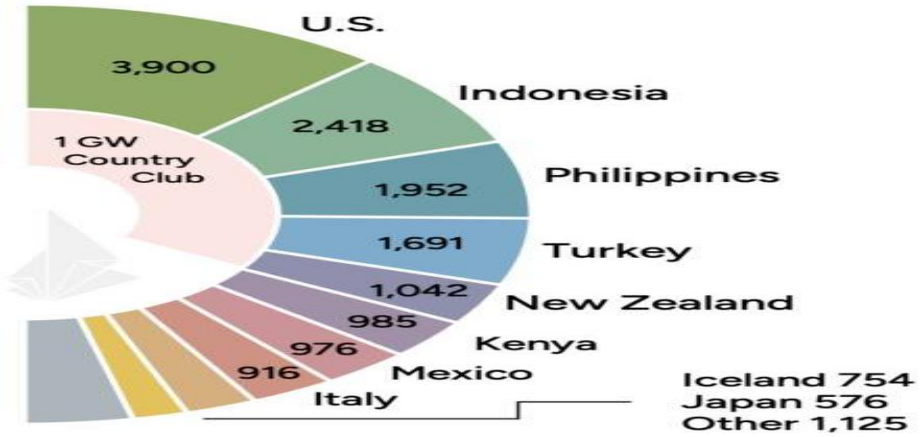

Figure 1. The world 10 top countries utilizes geothermal energy for producing electricity.

2. Analysis of Economic Issues Associated with Egyptian-African Geothermal Power Plant Project 60-MW

Kenya is considered the first country in Africa which utilizes geothermal energy resources for producing electricity. There are many geothermal power plants in Kenya located the western region in Kenya. Once Kenya is one of three countries which sharing Victoria lake, the origin of the Nile river, with Tanzania and Uganda, Then, Egyptian government must plan to sharing sustainable development in Kenya, Tanzania, Uganda as well as Ethiopia which has Tana lake, the second origin of the Nile river. So, Egyptian-African geothermal power plant project will be planned to produce 60-MW electricity consists of two 30-MW steam turbines which are driven by 12 geothermal reservoir wells. Each geothermal well will be expected to supply thermal energy between 4 to 5 MW. The location of Egyptian-African geothermal power plant project will be near Olkaria region, 150-km from Nairobi, Capital of Kenya which have great geothermal energy resources [4 and 5].

Geothermal energy researchers have been supported by specialist companies and governmental institutions to obtain the optimum results of geothermal energy projects in East African countries like Kenya, Ethiopia and Djibouti. So, the first exploratory wells were drilled in Olkaria (Kenya), Tendaho and Aluto (Ethiopia) and Asal (Djibouti). Most of geothermal energy projects in Kenya, Ethiopia and Djibouti are discontinuous because of aid loss by governments and loss of geothermal energy professional researches. Faculty of African Postgraduate Studies, Cairo University, Giza, Egypt qualifies more geothermal energy researchers with cooperation of Faculty of Engineering, Cairo University, Giza, Egypt. Also, New and Renewable Energy Authority NREA, Cairo, Egypt provides technical and financial aids to geothermal energy researchers for satisfying the sustainable development in Egypt and African countries. Figure (2) shows the map of geothermal energy resources in Eastern African Region [6].

Figure 2. The map of geothermal energy resources in Eastern African Region.

Utilization of geothermal energy resources can be classified into two categories. These categories are direct use and electricity generation. Direct use of geothermal energy is older than electricity generation based on geothermal energy utilization. So, direct use of geothermal energy depends on heating itself usage like housing heating system, industry bathing and agriculture purposes. In addition, utilization of geothermal energy resources for producing electricity requires high temperate and pressure rate of supplies geothermal energy resources to sustain the safe and continuous operation of the driven steam turbine which is coupled to the alternative generator for producing electricity. So, Kenya and Ethiopia have the sufficient geothermal energy resources suitable for producing electricity. Figure (3) shows the geological locations of geothermal energy resources hot spots in Kenya [7 and 9].

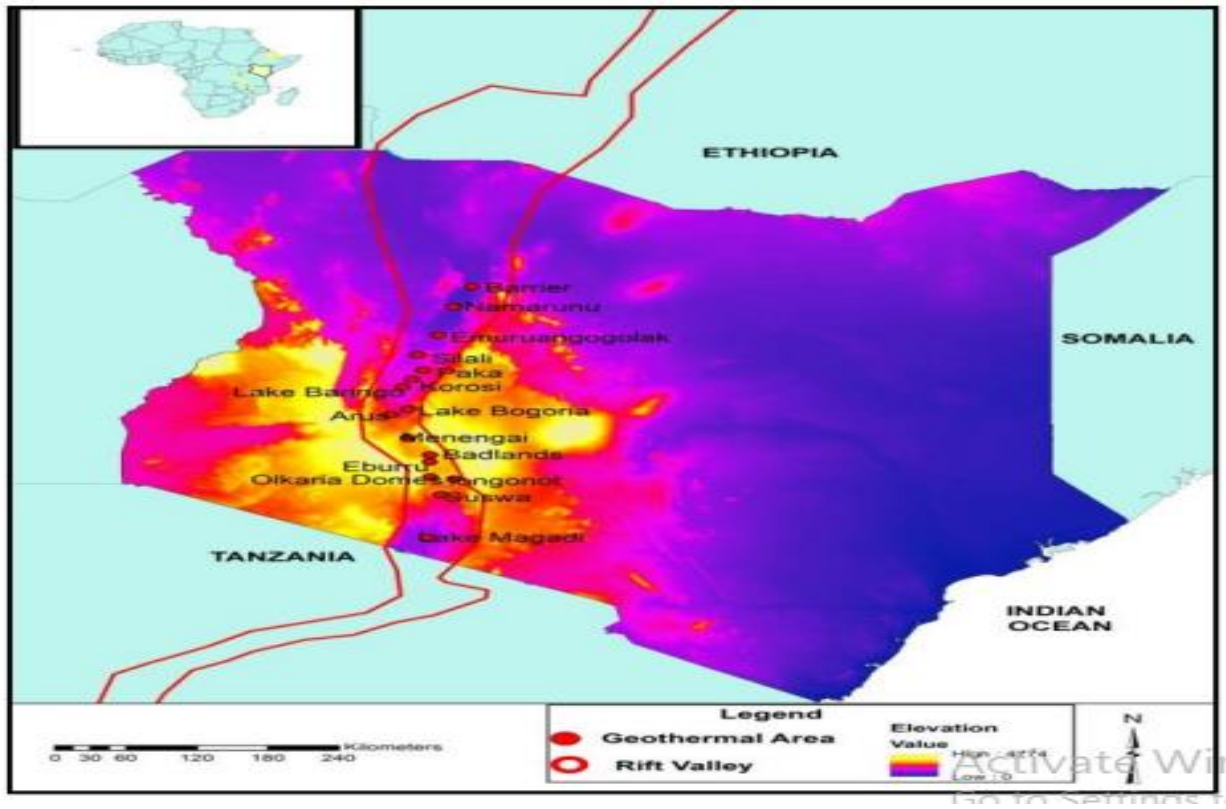

Figure 3. The geological locations of geothermal energy resources hot spots in Kenya.

Geothermal energy usages have wide range of temperature depend on type of usage direct use or electricity generation. In direct us, temperature range of the geothermal energy heating system is between 50 to 80 °C, while in electricity generation the steam temperature which drives steam turbines must be not less than 235 °C to prevent cavitation occurrence and damage of steam turbine blades. In few cases, the geothermal energy usages have combined heating system and electricity generation. So, it is called co-generation operation. In cold region, co-generation operation is normally used for satisfying sustainable development like in Ice Land, where 35% electricity generation depends on geothermal energy and the housing heating system depends on geothermal energy. In few cases, geothermal energy temperature is lower than minimum required temperature. Then, it can be upgraded to the required temperature by using electrical heat pumps [11].

3. Levelized Cost of Electricity LCOE

The main principle of energy generation cost is Levelized Cost of Electricity (LCOE). When planning of the proposed power generation plant project, Levelized cost of electricity must be evaluated. Then, LCOE can be defined as the charge price of electricity generation unity that provides customer with the needed power. Customers who buy electricity can select the best and lowest charge price of electricity generation unit. In other words, Investors must plan to purchase power generation plants supply electricity with the lowest Levelized Cost of Electricity to find more customers and can increasing the investment of electricity generation plants. The difference between purchase of power generation project and its revenues during an identified period of time can be evaluated. This expression can be denoted by the project cash flow. In this study, evaluation of cash flow for the proposed power generation project will be at the end of one year. Then, time t is symbolized to the year-end [8].

The project cash flow for the period t can be symbolizes as CFt. It is defined as the sum of differences between the power generation project costs (Ct) and its revenues (Rt) during the previous year end (t-1) and the next year end (t). The cost and revenue of proposed power generation project during its life time

can be evaluated by financial and technical standards. The Net Present Value NPV of power generation project can be evaluated by summation of its discounted cash flow. The power generation project discount factor can be symbolized by d. Then, the Net Present Value NPV of the proposed power generation project can be evaluated by using both equation (1) and equation (2) [8].

$$\text{NPV} = dCF_1 + d^2CF_2 + d^3CF_3 + \cdots + d^TCF_T \quad (1)$$

$$= d(R_1 - C_1) + d^2(R_2 - C_2) + d^3(R_3 - C_3) + \cdots + d^T(R_T - C_T) \quad (2)$$

Where, NVP: is the net present value of power generation project.
Ct : is the project cost.
Rt : is the revenue.
t : is the end of period.
d : is the discount factor.

The Egyptian-African Geothermal Power Plant Project 60-MW has planned to generate electricity supplied to the Kenyan National Electric Grid. The cost of electricity generation (P) must be evaluated to obtain the Net Present Value NPV. Then, if the value of NPV is positive, the investors will purchase the Egyptian-African Geothermal Power Plant Project 60-MW. On the other hand, if the value of NPV has lower value but the electricity generation cost still has positive value (P′), the investors still plan to purchase the project. Otherwise, if the electricity generation cost is negative, this leads to the Net Present Values of the Egyptian-African Geothermal Power Plant Project 60-MW will be negative. Then, investors will plan to purchase another power generation projects. Finally, the lowest accepted value of NPV to purchase Egyptian-African Geothermal Power Plant Project 60-MW equal zero and this mean that project is strategic and non-profit project which can supply the people in Kenya with demand electricity [8 and 10].

Also, the Egyptian-African Geothermal Power Plant Project 60-MW is the best choice of power generation project in Kenya and clean environment project. This project will produce 60-MW electricity with no emissions as fossil fuel power generation plants. Although, the Egyptian-African Geothermal Power Plant Project 60-MW has high purchase cost compering to fossil fuel power generation plants, but it can considered the best choice for power generation plant because geothermal power plants projects has high rate of capacity factor comparing to other types of renewable power generation plants. Table (1) shows the evaluated electricity generation cost for different types of power generation plants [8].

Table 1. The evaluated electricity generation cost for different types of power generation plants.

Power Generation Type	Expected Capital Cost ($/KW)
Natural Gas: Combined Cycle	$ 1019
Coal	$ 3.607
Hydroelectric: Conventional	$ 3.915
Nuclear: dual unit	$ 6.144

Geothermal power plants projects depend on drilling geothermal energy wells at depth around of 11000 ft. So, Egyptian Ministry of Petroleum and Mining Resources have owned two drilling companies like Egyptian Drilling Company EDC and Modern Drilling Company MDC. These two companies are

owned completely to the Egyptian government and lead to reduce the Levelized Cost of Electricity LCOE through establishment of geothermal power plants projects in Kenya and Ethiopia. So, Egyptian Government must establish Egyptian National Geothermal Energy Company responsible for geothermal projects development inside and outside Egypt. Ethiopia has the greatest geothermal energy resources in Africa, although Kenya is considered the unique African countries that utilizes geothermal energy resources for producing electricity. So, Egyptian government must plan to establish many geothermal power plants projects in Ethiopia to support Ethiopian Government for satisfying the sustainable development in Ethiopia [11and 12].

African countries have large percent of uranium ores resources in the World. Niger, Namibia, South Africa, Botswana and Tanzania have percent of 7%, 6%, 6%, 1% and 1%, respectively of the uranium ores resources in the World that can provide fuelling of El-Dhabaa Nuclear Power plant in Egypt and support expansion of nuclear power plants projects in Egypt like the proposed Safaga Nuclear Power Plant Projects in Red Sea Governorate, Egypt. Figure (4) shows the percent of uranium ore resources in all the World [1 and 10].

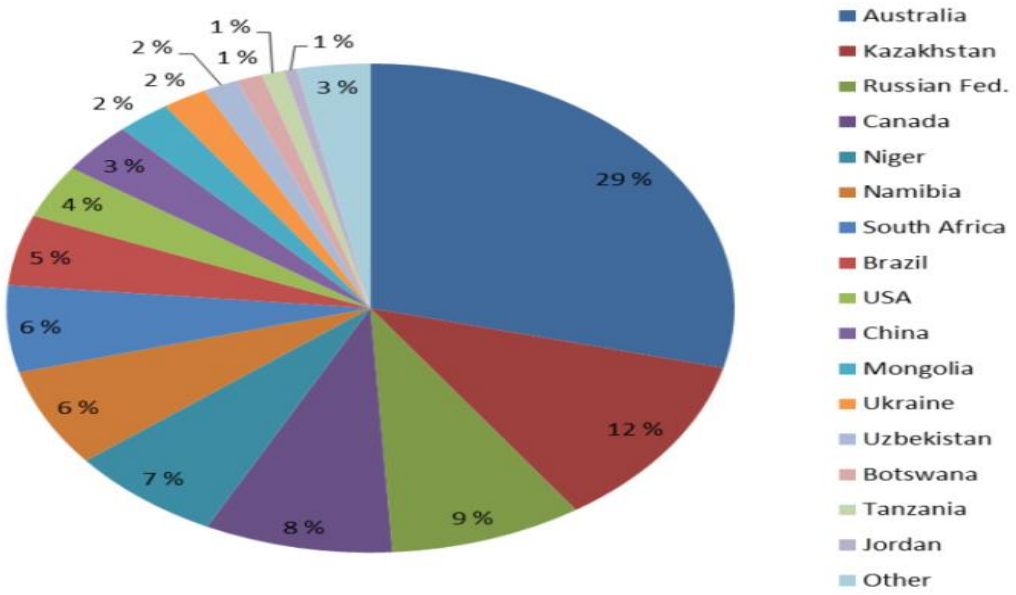

Figure (4). Percent of uranium ores resources in the World.
(Other includes: Pakistan, Malawi, India, Romania, Czech Republic and France)

4. Environmental and Safety Issues Associated with Deployment of Geothermal Power Plants Projects in Kenya

Both environmental and safety factors are the most important for selecting the type of power generation plants projects. In crowded people area, Power generation researchers don't prefer to establish fossil fuel electricity generation plants projects to eliminate carbon dioxide emissions CO_2 which have passive environmental impact to the surrounding environment. So, Renewable energy power generation plants projects are the best environmental and safety choice because they have no greenhouse emissions to the surrounding atmosphere. Hazards in drilling geothermal wells and H_2S emissions cause misunderstanding in media and leads to analyze safety measures of geothermal power plants projects [14].

Although, nuclear power plants accidents are fatal but they never occurred in safe environmental operation. There are only three nuclear accidents on the history of power plants projects when Russia started operation of the first nuclear power plant in 1952. Most of these nuclear accidents due to natural phenomena and life time of this nuclear power plant was expired although it was in continuous operation. In addition, low rate of accidents in geothermal power plants projects can be compared with nuclear power plants projects. So, the whole history of geothermal power plants accidents have the

lowest number of annual fatalities compared with other types of renewable energy power plants and fossil fuel power plants World Health Organization WHO have prepared statistics of global accidents and mortality conditions per billion KWh occurred at different types of power generation plants. Table (2) shows rate of accidents mortality rate per billion KWh for different type of electricity generation plants [10 and 13].

Table 2. Accidents and Mortality Rate per Billion KWh for Different Types of electricity generation Plants

Types of Power Plant	Rate of Mortality per billion KWh
Nuclear Plants	0.04
Oil-fired Plants	36
Natural gas-fired Plants	4
Coal-fired Plants	100
Hydro Plants	104
Wind Plants	0.15
Solar Plants	0.44

5. Conclusion

This paper has examined economic, environmental and safety prospects for development of natural resources in the African countries which have origins of the Nile River like Uganda, Tanzania, Kenya and Ethiopia, as well as encourage for development of natural resources in Egypt, especially Egypt had planned the climate change conference COP-27 in Sharm El-Shiekh, Egypt, December 2022. There are many factors influencing economic, environmental and safety issues associated with geothermal power plants projects in Africa. These factors are political and social to avoid causes of climate change. So, Egyptian government sharing sustainable development in African country to make international rank of Egypt among the greatest counties in the world. Egyptian-African geothermal power plants projects 60-MW is considered the greatest renewable energy projects in Africa which make Egyptian government cooperate with all African countries governments to achieve their sustainable development like cooperation between Egyptian and Kenyan governments to establish this geothermal power plants.

Egyptian government investments in natural resources of African countries are considered the most important strategy associated with Egyptian national security requirements, especially in African countries that have Victoria Lake and Tana Lake, origins of Nile River, like Kenya, Tanzania, Uganda and Ethiopia to enhance the common sustainable development in Egypt and these African countries. Development of earth natural resources in African countries which have high amount of the uranium ores resources like Niger, Namibia, South Africa, Tanzania and Malawi must be the main strategies of the Egyptian government to ensure nuclear fuelling during commercial operation of El-Dhabaa Nuclear Power Plant in 2028 and also for expansion of nuclear power plants in Egypt. Ethiopia has great amount of geothermal energy resources like Kenya, but it has no geothermal power plant producing electricity. So, establishment of the first geothermal power plant project in Ethiopia leads to increasing sustainable development in African countries and providing electricity to 120 million people in Ethiopia, and they depend on low rate of electricity around 5500 MW.

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